CLAIMS

1   1. A method for providing an on-disk representation of a named data stream associated

2   with at least one of a directory inode and file inode of a file system of a network storage

3   appliance, the method comprising the steps of:

4   allocating a first free inode of the file system;

5   inserting a stream_dir type into a first type field of the first free inode to thereby

6   convert the first free inode to a stream directory inode, the stream directory inode having

7   a first data section with a first pointer configured to reference a stream directory data

8   block;

9   modifying a xinode field of the file inode to reference the stream directory inode;

10   allocating an entry of the stream directory data block to store a name of the named

11   data stream, the allocated entry further allocating a second free inode of the file system;

12   and

13   inserting a stream type into a second type field of the second free inode to convert

14   the second free inode to a stream inode for the named data stream, the stream inode hav-

15   ing a second data section with a second pointer that references a user data block associ-

16   ated with the named data stream.

1   2. The method of Claim 1 further comprising the step of assigning a third pointer to the

2   allocated entry of the stream directory data block that references the stream inode.

1   3. The method of Claim 1 wherein the step of allocating a first free inode comprises the

2   step of asserting a predetermined flag within the file inode to transform the file inode into

3   a base inode having more than one data fork.

1   4. The method of Claim 3 wherein the predetermined flag is a WAFL_flag_stream flag.

1   5. The method of Claim 1 further comprising the steps of:

2   loading a root inode and its referenced data blocks from a disk into a memory of

3   the network storage applicance; and

4   searching contents of the root inode data blocks for a directory name of the di-

5   rectory inode.

1   6. The method of Claim 5 further comprising the steps of:

2   upon finding the directory name, loading the directory inode and its referenced

3   data blocks into memory; and

4   searching contents of the directory inode data blocks for a filename of the file

5   inode.

1   7. The method of Claim 6 further comprising the step of, upon finding the filename,

2   loading the file inode and its referenced data blocks into the memory.

1   8. A system for providing on-disk representations of multiple named data streams within

2   a filer, the system comprising:

3   a processor;

4   a memory coupled to the processor and having locations addressable by the proc-

5   essor;

6   at least one disk coupled to the memory and processor; and

7   an operating system resident in the memory locations and invoking storage op-

8   erations in support of a file system configured to logically organize information as a hier-

9   archical structure of directory and file inodes on the disk, each named data stream stored

10 on the disk as a representation embodying a stream inode associated with a file inode,

11 each on-disk file inode having a default data stream and at least one named data stream

12 inode.

1   9. The system of Claim 8 further comprising a storage adapter interconnected with the

2   processor, memory and disk, the storage adapter cooperating with the operating system to

3   access the information stored on the disk.

1   10. The system of Claim 8 further comprising a network adapter coupled to the processor

2   and memory of the filer, the network adapter connecting the filer to a client over a com-

3   puter network, the client interacting with the filer by exchanging packets encapsulating a

4   record requesting file services from the filer using a file system protocol over the net-

5   work.

1   11. The system of Claim 10 wherein the file system protocol is a Common Internet File

2   System (CIFS) protocol and wherein the record is a CIFS record comprising information

3   pertaining to an operation directed to the named data stream.

1   12. The system of Claim 11 wherein the operating system comprises a series of software

2   layers, including a file system protocol layer configured to support the CIFS protocol and

3   a Write Anywhere File Layout (WAFL) layer configured to implement the file system.

1   13. The system of Claim 12 wherein the CIFS record is interpreted as directed to a

2   named data stream associated with a file and transformed into a message structure by the

3   CIFS layer, and further passed to the WAFL layer, where the operation is performed.

1   14. The system of Claim 13 wherein the message is passed from the CIFS layer to the

2   WAFL layer as a function call.

1   15. The system of Claim 13 wherein the WAFL layer loads the stream inode from disk

2   into memory and accesses the stream inode as instructed by the operation.

1   16. The system of Claim 12 wherein the operating system further comprises a media ac-

2   cess layer of network drivers, network protocol layers, a disk storage layer that imple-

3   ments a disk storage protocol and a disk driver layer that implements a disk access proto-

4   col.

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1   17. The system of Claim 16 wherein a storage access request data path through the oper-

2   ating system layers enables performance of data storage access for the client request re-

3   ceived at the filer.

1   18. The system of Claim 17 wherein the storage access request data path is implemented

2   as logic circuitry embodied within a hardware circuit.

1   19. A computer readable medium containing executable program instructions for pro-

2   viding an on-disk representation of a named data stream associated with at least one of a

3   directory inode and file inode of a file system, the executable program instructions com-

4   prising program instructions for:

5   allocating a first free inode of the file system;

6   inserting a stream_dir type into a first type field of the first free inode to thereby

7   convert the first free inode to a stream directory inode, the stream directory inode having

8   a first data section with a first pointer configured to reference a stream directory data

9   block;

10   modifying a xinode field of the file inode to reference the stream directory inode;

11   allocating an entry of the stream directory data block to store a name of the named

12   data stream, the allocated entry further allocating a second free inode of the file system;

13   and

14   inserting a stream type into a second type field of the second free inode to convert

15   the second free inode to a stream inode for the named data stream, the stream inode hav-

16   ing a second data section with a second pointer that references a user data block associ-

17   ated with the named data stream.

1   20. Apparatus for providing an on-disk representation of a named data stream associated

2   with at least one of a directory inode and file inode of a file system of a filer, the appara-

3   tus comprising:

4   means for allocating a first free inode of the file system;

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5   means for inserting a stream_dir type into a first type field of the first free inode

6   to thereby convert the first free inode to a stream directory inode, the stream directory

7   inode having a first data section with a first pointer configured to reference a stream di-

8   rectory data block;

9   means for modifying a xinode field of the file inode to reference the stream di-

10 rectory inode;

11   means for allocating an entry of the stream directory data block to store a name of

12 the named data stream, the allocated entry further allocating a second free inode of the

13 file system; and

14   means for inserting a stream type into a second type field of the second free inode

15 to convert the second free inode to a stream inode for the named data stream, the stream

16 inode having a second data section with a second pointer that references a user data block

17 associated with the named data stream.

1   21. A storage system for providing on-disk representations of multiple named data

2 streams within a computer, the system comprising:

3   an operating system resident in a memory and invoking storage operations in sup-

4 port of a file system configured to logically organize information as a hierarchical struc-

5 ture of directory and file inodes on the disk, each named data stream stored on the disk as

6 a representation embodying a stream inode associated with a file inode, each on-disk file

7 inode having a default data stream and at least one named data stream inode.

1   22. A method for accessing an on-disk representation of a named data stream associated

2 with at least one of a directory inode and file inode of a file system of a server computer,

3 the method comprising the steps of:

4   sending a packet from a client to the server over a network medium, the packet

5 encapsulating a record requesting a file service directed to the named data stream;

6   creating a message from the record and passing the message to a file system layer

7 of the server;

8   loading a stream inode and a referenced data block for the named data stream

9 from a disk into a memory of the server; and

10   processing the stream inode in accordance with the requested file service.

1 23. The method of Claim 22 wherein the requested file service is a write operation.

1 24. The method of Claim 23 further comprising the steps of:

2   loading a base inode of the stream inode from the disk into the memory;

3   updating a modification time stamp stored in the base inode for the named data

4 stream;

5   updating the referenced data block as instructed by the write operation;

6   marking the referenced data block, the base inode and the stream inode dirty; and

7   flushing the marked block and inodes to the disk.

1 25. The method of Claim 22 wherein the requested file service is a read operation.

1 26. The method of Claim 25 further comprising the steps of:

2   loading a base inode of the stream inode from the disk into the memory;

3   updating an access time stamp stored in the base inode for the named data stream;

4   retrieving data contained in the referenced data block for delivery to the client;

5   marking the base inode dirty; and

6   flushing the marked inode to the disk.

1 27. A method for accessing an on-disk representation of a named data stream associated

2 with at least one of a directory inode and file inode of a file system of a server computer,

3 the method comprising the steps of:

4   sending a packet from a client to the server over a network medium, the packet

5 encapsulating a record requesting a file service directed to the named data stream;

6   creating a message from the record and passing the message to a file system layer

7 of the server;

8   loading a base inode referenced by a file handle of the message from a disk into a

9 memory of the server;

10   determining whether a predetermined flag of the base inode is asserted and, if so,

11 loading a stream directory inode referenced by the base inode, along with a stream di-

12 rectory block referenced by the stream directory inode, into the memory;

13   loading a stream inode for the named data stream referenced by the stream direc-

14 tory block into the memory; and

15   retrieving (i) a name of the stream inode from the stream directory block and (ii) a

16 size of the stream inode from the stream inode for delivery to the client.

1 28. A multi-protocol data access storage system for providing on-disk representations of

2 multiple named data streams within a computer, the system comprising:

3   an operating system resident in a memory of the computer and invoking storage

4 operations in support of a file system configured to logically organize information as a

5 hierarchical structure of directory and file inodes on the disk, the operating system in-

6 cluding a file system protocol layer configured to provide data access in support of a plu-

7 rality of file system protocols, each named data stream stored on the disk as a representa-

8 tion embodying a stream inode associated with a file inode, each on-disk file inode hav-

9 ing a default data stream and at least one named data stream inode.

1 29. The multi-protocol data access storage system of Claim 28 wherein one of the file

2 system protocols is a Common Internet File System (CIFS) protocol.